IN OUR RIGHT MIND

Our brains have been getting smarter in response to modern life, but a surprising new study suggests the trend may have peaked. So how can you maximise your thinking? **by KATE EVANS**

Can you solve this problem? You have a wolf, a goat and a cabbage, and you need to get all three across a river in one piece. You have a boat, but it's so small that it can fit only you and one of the items, and you can't leave the wolf and the goat or the goat and the cabbage alone together. How do you get them all across?

This classic logic puzzle is at least a thousand years old. It is attributed to Alcuin of York, a medieval poet and scholar who died in 804, though it probably circulated in oral form before then. There's another version with a fox, a goose and a bag of beans, and a related tale about three lascivious (but jealous) husbands and their wives who must also be ferried across a river without any hanky-panky on the boat or the shore.

Similar riddles are found across Africa, too. There is a traditional Liberian variation involving a cheetah, a fowl and some rice, though two can be carried on the boat; and a Zambian one with four objects – a leopard, a goat, a rat and a basket of corn – that also must be taken across the river.

According to one historian, these different logical structures suggest the brainteaser arose spontaneously in each of the cultures – implying that mathematical thinking and the enjoyment of puzzles is a universal trait (and, perhaps, that getting a collection of unwieldy things across a body of water has been a common problem in history).

From campfire riddles and murder mysteries to cryptic crosswords and Sudoku, the human brain loves to tangle with a puzzle – a rehearsal, perhaps, for the serious and real problems we must confront in our jobs and personal relationships and as a society.

"Fifteen years ago, being creative was a synonym for being disorganised. Now we want people to think outside the box."

The global challenges facing humanity – from climate change and fake news to automation – are much more complex than getting a goat safely across an imaginary river. Perhaps the ultimate recent example of problem-solving was the rescue of the Thai boys from the cave. It was superb teamwork and incisive thinking based on real experience and observation that got the boys out, not Elon Musk and his singular approach. So, are we doing enough to teach people how to think critically and solve problems? What is happening in the brain when we do it? And are we getting better at it – or worse?

The rescue of the Thai boys is a stunning example of problem-solving.

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AHA MOMENTS/THINKING OUTSIDE THE BOX

Neuroscientists have identified two main ways we solve problems: either by analysis – methodically testing possible solutions by trial and error, as in a labyrinth – or by insight, a "light-bulb" moment where the answer pops into your head fully formed.

Carola Salvi is an Italian post-doctoral researcher at the creative brain lab at Northwestern University in the US, which specialises in exploring these insight moments. She got into the field when it was still niche and indie, she says – these days, though, creative problem-solving is trendy.

"A big part of it is Silicon Valley. Fifteen years ago, being creative was a synonym for being disorganised. Now we don't want people to be rigid, we want people to be original, to think outside the box, to connect unexpected things. You even see it in advertising: what's considered aesthetically sexy isn't someone in a suit, it's a creative-looking guy, an artist with a beard. Google created this culture, I think, but that flows on to science, too."

Salvi and her colleagues are investigating what happens in the brain when people

solve problems.

"Every time you have a goal and you don't know how to reach it, you have a problem. Solving that problem starts with an initial search, and ends with the idea that solves it. We're interested in studying the idea generation," says Salvi.

There's a classic logic puzzle that asks players to draw four straight lines through nine dots that are arranged in three parallel rows. "There are no squares there, but you perceive that there is a square, and if you keep thinking of those nine dots as a square, you're never going to solve the problem."

As soon as you move beyond your initial assumptions and (spoiler alert) realise the straight lines can extend beyond the boundaries of the square, the solution is obvious. It's outside-the-box thinking – and some think this puzzle was the origin of the term.

"When you stop perceiving the square, when you restructure the initial representation of the problem, you can also consider the space surrounding the problem as part of whatever you're working on. That's the best metaphor I can think of to describe what happens with insight," Salvi says.

Salvi and her boss, Mark Beeman, devised a set of experiments to capture that fleeting "aha moment". In one, they gave each study subject sets of three words – for example, pine, crab and sauce – and asked them to find a fourth word that worked as a compound word or phrase with all of them.

Then they recorded cerebral activity, eye movements and other physiological measures while people tried to solve the problem.

The moment they had an answer (in this case, it's apple), they had to press a button and record whether they'd solved it via insight or analysis.

"We were able to identify a neural circuit that activates when people have an insight, and it's different compared to when people solve a problem via analysis. So, different parts of the brain are involved in these two ways of solving problems."

The scientists found evidence of the aha moment in the brain milliseconds before the subject pressed the button. But when they looked further back, at what was happening in the brain a full second or two before, they found something else.

"We saw alpha waves, which correspond to the frequency of the brain's electrical activity of when you are engaged in conscious but really relaxed thinking – like just before you fall asleep, when you are conscious but you're not actively thinking."

Carola Salvi: "Different parts of the brain are involved in the two ways of solving problems."

They also found reduced activity in the visual cortex, which suggested to Salvi that something might be going on in our visual and attention system when we have insights. So her next study looked at people's eye movements while they solved a tricky problem. "When we solve problems via insight, we tend to blink more and for longer periods – we're physically blocking the amount of information that's getting into our minds. And when we're not blinking, we tend to do like this …"

We're talking over Skype, and Salvi looks up, as though she's trying to get a glimpse of her eyebrows. I immediately recognise it as a "concentrating face".

Artist Paul Gauguin said, "I close my eyes in order to see", Salvi tells me, and that's what she thinks is happening here.

"To solve a problem creatively, to have an insight, our brain tends to escape visual distractors, to physically block information, and to look somewhere else. You don't want to overload your mind with visual information, because you want to focus more inwardly, and you get into this 'offline mode' where you're very pensive.

"That's why they say people have their best insights when they're having a shower, just about to fall asleep or when they're taking a bath, like Archimedes with his famous eureka moment."

And these light-bulb moments aren't just lucky guesses, Salvi says. In a third set of experiments, her team tested hundreds of students and found that when they solved problems via insight, 94% of the time they were correct, compared with 78% when they used analysis.

"So, when you have an insight – that solution that pops into your mind out of nowhere – you should trust it, because it's probably the correct one."

A BETTER BRAIN?

Regardless of which method we use, it seems humans, on average, are better at solving these kinds of problems than they were a

century ago. Since the 1930s, the average scores on IQ tests have risen steadily – about three points per decade – and scores have increased the most on the problem-solving portion of intelligence tests.

There's still some mystery surrounding why it is happening, but it's been proposed that the increases are the result of a combination of improved nutrition, smaller family sizes, better education, more intellectually demanding work, a more complex and stimulating cultural environment and people being more accustomed to abstract thinking and the kinds of questions asked in IQ tests.

The trend is called the "Flynn Effect", after University of Otago emeritus professor of political studies James Flynn, who first identified it. Now in his eighties, he is an expert in human intelligence, but he cautions against the assumption that people today are necessarily smarter than they were 100 years ago.

A 2018 study found that Norwegian men's IQ scores are measurably lower today than their fathers' at the same age.

Expert in human intelligence James Flynn: our brains don't have more genetic potential.

Our brains certainly don't have more genetic potential, he says. "In just three generations, evolution hasn't produced a better brain." They would, however, look different in an autopsy. "The brain is a sort of muscle, and people today do different mental exercise than they did in 1900. They would be equally intellectually adapted to their environment, but if you transported one of them by magic to our environment, they, of course, would be out of kilter, but what would you expect?"

Modern society makes more demands on us – and our brains respond.

"My father and his brothers went into factory work between the ages of 11 and 14, so if you gave them a test at the age of 25, their minds would not have shifted to the same degree as a person's mind has shifted today."

Recent research, however, suggests that in industrialised countries, the gains in IQ have tapered off or even fallen. A 2018 study found that Norwegian men's IQ scores are measurably lower today than their fathers' at the same age. Those born in 1991 scored about five points lower than those born in 1962. Research from Britain and other Scandinavian countries seems to suggest a similar trend, although there's none available for New Zealand.

Analysis of more than 730,000 IQ test results by researchers from Norway's Ragnar Frisch Centre for Economic Research showed the Flynn effect peaked for people born during the mid-1970s and has declined significantly since then. Researchers noted that IQ drops occurred within families, between fathers and sons, which suggested that changes in lifestyle could be behind the lower IQs.

One possibility for the change is perhaps the result of the way children are educated and parented, as well as the things they spend time doing, such as different forms of play and whether they read books.

Another possibility is that IQ tests haven't adapted to accurately quantify an estimate of 21st-century people's intelligence, because they favour forms of formally taught reasoning that may not get as much attention in modern education.

"Intelligence researchers make a distinction between fluid and crystallised intelligence," says research economist Ole Røgeberg, one of the study's authors. "Crystallised intelligence is stuff you have been taught and trained in, and fluid intelligence is your ability to see new patterns and use logic to solve novel problems."

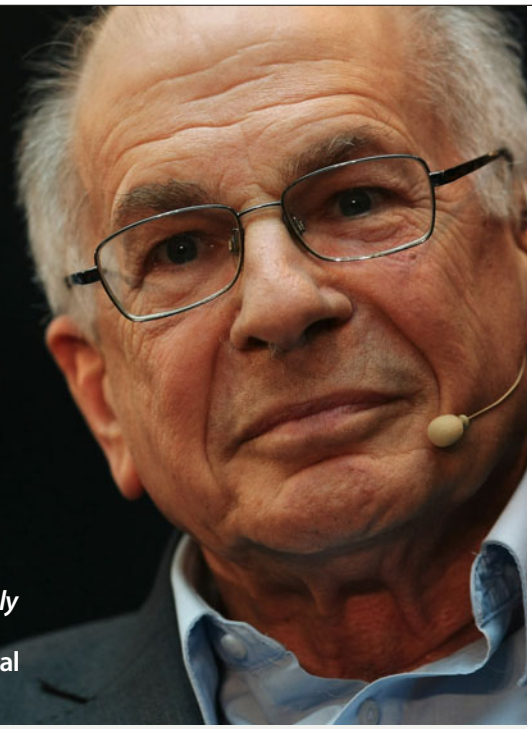
A tapering off in intelligence gains isn't particularly surprising. Average family sizes can't get much smaller than they are, says Flynn, and "we can't really make people go to school much more than they do or we'd be going to school our entire lives". But why are they falling?

McDONALD'S JOBS

Flynn's hypothesis is that compared with 30 years ago, we're doing less cognitively demanding work. Automation has resulted in more service work: "We're even going to automate lawyers out of existence. The sorts of jobs that are expanding are McDonald's

DAVID WHITE

How we make decisions



The work of Daniel Kahneman, right, with collaborator Amos Tversky remains among the most frequently cited in the social sciences. It earned him the Nobel Prize in Economics in 2002 and laid the foundations for behavioural economics, the study of how people actually make decisions, rather than how they ought to as rational agents. This in turn has inspired a spate of bestsellers – *Freakonomics*, *Nudge*, *Black Swan* and *Predictably Irrational* among them – and Kahneman's own book for general readers, *Thinking, Fast and Slow*.

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BIASES THAT DRIVE US

THERE ARE DISTINCT PATTERNS, says Daniel Kahneman, in the errors people make based on the predictable biases in thinking. "When the handsome and confident speaker bounds onto the stage, for example, you can anticipate that the audience will judge his comments more favourably than he deserves. The availability of a diagnostic label for this bias – the **halo effect** – makes it easier to anticipate, recognise and understand." Here are some common biases:

The anchoring effect: We adjust our estimates to accommodate arbitrary numbers. For example, a study of experienced German judges showed that sentencing could be influenced by first rolling a pair of dice. When they rolled a three, they sentenced a (hypothetical) shoplifter to an average of five months' jail. If they rolled a nine, the average sentence was eight months.

The availability heuristic: We base our judgments on readily available memories. For example, Americans judge death by accident to be 300 times as likely as death by diabetes; the true figure is about 1.7. This misjudgment, Kahneman argues, reflects our taste for "novelty and poignancy", compounded by our exposure to grisly instances in the media.

The affect heuristic: We put too much weight on judgments that are emotionally laden.

Base-rate neglect: We accept what is causally possible over what is statistically probable.

Competition neglect: We expect outcomes to be determined by our efforts alone, not the influence of competitors.

Hindsight bias: We overestimate the accuracy of our past predictions, believing that we knew it all along.

The illusion of skill: We attribute success to talent rather than luck.

The illusion of validity: We hold on to our beliefs in the face of contradictory evidence.

The planning fallacy: We plan around best-case scenarios rather than what is statistically likely.

Loss aversion: We are more averse to losses than we are attracted to equivalent gains.

Narrative fallacy: We create coherent causal stories to make sense of haphazard events.

Representativeness bias: We lean heavily on stereotypes to compensate for partial information.

The sunk-cost fallacy: We continue investing in an established project rather than focus on its future outcomes.

jobs. People learn a lot of problem-solving skills on the job. If your job demands that you think in a lively way, that part of your brain gets more exercise. If your job doesn't demand much, it atrophies."

He also thinks we spend too much time playing video games and on social media and not enough reading serious novels or history. But others have speculated that the digital age just demands a new kind of intelligence that IQ tests designed in the mid-20th century are not good at measuring.

Even if it's true that as a population, we're getting less smart, does it matter?

"From the point of view of having a critically alert citizenry, these recent intellectual trends are certainly disturbing," says Flynn.

We're going to need all the problem-solving skills we can muster to tackle climate change, another of Flynn's pet topics (he advocates for large-scale climate engineering, using sea spray to brighten the clouds and cool the Earth, to buy us enough time to transform our economies).

But coming up with workable solutions is only one part of solving real-world problems, he says. We also need to overcome political and emotional obstacles. "We're spoilt. We don't want to hear anything that tells us we have to cut back on production and may have to have fewer consumer goods. People aren't just thinking machines. The problem is not just intellect, but character."

QUICK AND DIRTY RULES

Character aside, can problem-solving be taught? University of Auckland philosophy professor Tim Dare thinks it can, and that there's still plenty of room for improvement, especially when it comes to critical thinking.

When we make arguments and solve problems, he says, we tend to rely on "heuristics". These are "quick and dirty rules" or mental shortcuts that save time, but frequently don't lead us to the right results.

A swag of fallacious ways of thinking fall into this category of "thinking fast", as Nobel Prize-winning psychologist Daniel Kahneman called it. He and a colleague first identified some of them in the 1970s, including the "availability heuristic" – our tendency to estimate how frequently an event occurs based on how easily we can think of an example. People overestimate their chances of dying in a tornado or terrorist attack, whereas mundane (but more common) deaths from asthma or diabetes are harder to bring to mind.

There's also the "anchoring effect",

University of Auckland's Trudi Gwillim. Right, students doing "Solve It" problem-solving.

where people try to estimate a number but are influenced by an arbitrary figure they already have in their head. Kahneman had people spin a wheel of fortune (rigged to stop at 10 or 65), then estimate the percentage of African nations in the UN. Those who saw 10 on the wheel before answering the question consistently gave much lower estimates than those who saw 65, even though they knew the two things were totally unrelated.

Dare aims to teach people to overcome these faulty shortcuts and make decisions more carefully by using critical thinking. He formerly taught the university's first-year philosophy course on the subject – it attracts as many as 1000 students a semester. Now, he "virtually" leads the university's Massive Online Open Course (Mooc) on logical and critical thinking, which runs three times a year. Anyone from anywhere in the world can sign up for free. Dare explains key concepts in short, entertaining videos, and there are articles, quizzes and discussion forums. Demand is high – 100,000 students in 130 countries have signed up for the course since it started in 2015.

"I get sweet notes from people all around the world, saying, 'I've done your course and it helped me win my arguments with my brother,'" Dare says.

But can an online course or a semester of university really change our thinking in the long term? "The news is not all that good, as far as we know," says Dare. Researchers have tested people's critical thinking skills before they start a course like this, he says. "When you test them afterwards, it often has made quite a difference. But if you test them six months later, people often slip back into old habits."

In an era where we're surrounded by social-media echo chambers and fake news, being able to critically evaluate an argument has never been more important. Dare suspects we need to start much younger – "the moment kids get to school, or even the moment you start talking to them".

"If I'm good at solving problems, I will be more likely to survive – so it makes sense that you have this release of dopamine that makes it a little bit addictive."

The University of Auckland's centre for innovation and entrepreneurship is also teaching problem-solving to university students, though in a more immersive and real-world way. An annual programme called "Solve It" attracts students from every faculty, who have two weeks to come up with solutions to real environmental and business problems posed by companies and council bodies. This year, they're working with Hynds, Auckland Transport and the Auckland District Health Board, and the problem topics include cycling to school and the care of live organ donors.

"They learn creative problem-solving, how to persevere through difficult times and how to work in multidisciplinary teams," says associate director Trudi Gwillim.

"You end up with business students sitting next to scientists, with an engineer and maybe a psychologist and an artist. It's quite incredible to see how they come at things from different angles, then together create this amazing solution by the end of it."

Students' solutions have been considered by the boards of several companies, and one year Ports of Auckland ended up employing some of the students as interns, and funding a student's PhD on a related topic.

Problem-solving skills are increasingly valued by employers, Gwillim says, and by students themselves.

"It's a challenging time for students to be at university," she says. "There's so much uncertainty about the future of work. They're studying towards something, but there's no guarantee that those jobs will even exist by the time they graduate.

"My dad left school at 13 to be a truck driver. He's 72 now, and still driving. He can't even believe I left my previous career, then ended up working at the university. Young people now are likely to have multiple careers over their lifetime, so what can we teach students that will benefit them

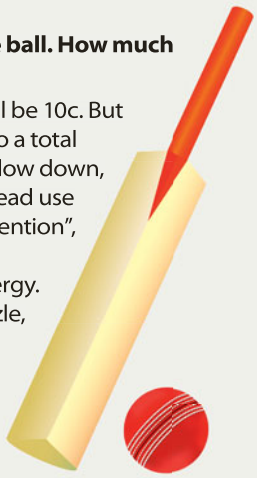
THE OLD BAT & BALL PROBLEM

A bat and ball cost $1.10. The bat costs $1 more than the ball. How much does the ball cost?

IF YOU ARE LIKE MOST people, your immediate answer will be 10c. But this is the wrong answer: a 10c ball and a $1.10 bat add up to a total cost of $1.20. To work out the correct answer, you need to slow down, to override the fast and frugal "shortcut" thinking, and instead use careful deliberation. (The answer is 5c.) We need to "pay attention", as the idiom goes, and we pay with mental effort.

Yet because the brain is an organ, this extra effort costs energy. Indeed, if you had to struggle to solve the bat and ball puzzle, you would have undergone some subtle physiological changes: your pupils would have dilated, your prefrontal cortex would have flushed with oxygen-rich blood and your consumption of glucose would have heightened.

– from Daniel Kahneman's Thinking, Fast and Slow.



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irrespective of what industry they go into?

"Creative problem-solving, dealing with ambiguity and uncertainty, and resilience are really important not just for university students but for all of us as life becomes busier and more complex. Problem-solving is a way of thinking, and the more opportunities you have to work on complex problems with a group of people who think differently to you, the more exercise your brain will get."

THROW AWAY THE KEY

You don't need to go to university or sign up for a Mooc to get a workout, though. Just grab a group of friends and lock yourselves in a room together. "Escape rooms" are a global trend that has recently arrived here. Each room is a themed game in which players have to solve a series of hands-on puzzles and riddles to unlock the room in the time allowed.

The first documented escape room opened in Japan in 2007, a real-life version of a popular computer game. But they really took off in Budapest. Social worker and team-building specialist Attila Gyurkovics was inspired by Hungarian psychologist Mihály Csíkszentmihályi's concept of "flow" – the focused mental state of concentration and creativity we get into when we're really immersed in something. Gyurkovics created his first escape room in Budapest in 2011, aiming to foster that flow among players. It worked – and the idea spread across Hungary and then the rest of the world.

There are now thousands of escape rooms in cities from Lima to Lisbon. In Auckland, there are at least 10 escape-game companies, with about 60 individual rooms to play around the country. You can escape from a prison cell, a Fiordland forest, Alice's Wonderland or a bach.

'Escape rooms' are a global trend – the most successful teams have a mix of genders and different thinkers.

Jayne Lusk runs Escapade, one of the early Auckland outfits. They've had 55,000 players through since they opened three years ago. People definitely get hooked, she says. "During the Lions tour, we had some All Blacks come in who I'm sure hadn't played before. They came back three times that same week.

"You really lose yourself in it for 60 minutes, you're taken to a different place and that's all you're focusing on. There's a little high each time you solve something and move to the next thing, and then there's the social side, that you're sharing that joy and experience with others."

In our digital age, there's something comfortingly analogue about it all, something the game designers seem to riff on – one I tried featured a cassette player, a slide projector, marbles and old pennies.

Lusk and her business partner design the games, which take about six months from concept to execution. "We use mechanical engineers, and we've had some intern students from the universities to help us on some aspects. Sometimes we might need an electrical specialist or a builder to come in and do something quite bespoke – we tap into all different kinds of expertise."

One of the most important design elements is ensuring the puzzles test the full spectrum of different personalities, she says.

"We want to make sure that whatever team comes in, everyone will have something to contribute, whether it's lateral thinking, attention to detail, or teamwork – we make sure there's a puzzle in there that you physically can't do by yourself." The most successful teams have a mix of genders and different kinds of thinkers, Lusk says.

Why are the rooms so popular? When we succeed at solving a tricky problem, our brain releases the "reward" neurotransmitter dopamine, explains cognitive neuroscientist Salvi. We have a sense of achievement, and increased self-esteem.

Salvi suspects there's an evolutionary aspect to this. Problem-solving enhances our ability to adapt: "If I'm good at solving problems, I will be more likely to survive compared with another person who's not as good at it – so it makes sense that you have this release of dopamine that makes it a little bit addictive. You want your brain to keep releasing this neurotransmitter that makes you feel rewarded."

Whether you're a team of Auckland corporates or a Liberian villager, problem-solving is fun. "Humans love doing this," she says.

Which brings us back to the riverbank. How do you get the wolf, the goat and the cabbage safely across? The aha moment, the key to unlocking the puzzle, is the realisation that you can bring an object back with you in the boat on your return trip.

Take the goat over first. Return and pick up the wolf, leaving it on the opposite shore – and take the goat back with you. Leave the goat there, then take the cabbage across, leaving it with the wolf on the far side. Finally, return for the goat. Problem solved. ▮

In response to popular demand, the Listener *now includes a logic puzzle in* Diversions *(see page 63).*

Jayne Lusk, who runs Escapade, an escape room game.

Smart solutions

Students are learning to think creatively and confidently.

From top, the St Cuthbert's College team; the winning Hukerenui School team.

How would you cope if you had 135 minutes to come up with solutions for a new kind of criminal justice system? Year 11 St Cuthbert's College students Grace Mora, Arabella Cryer, Amber Waymouth and Zoe Robinson had to do that in June when they travelled to La Crosse, Wisconsin, to put into practice what they had been training their brains to do.

Starting in Year 7, the college selects a small number of girls for extension "Future Problem-Solving" sessions. The concept was the brainchild of US creativity researcher Ellis Paul Torrance in 1974, and many schools now offer versions of it. Students learn to identify problems, research a complex topic, break down key issues and develop solutions. Each year, there's a national competition; this year's topics included cloud storage, philanthrocapitalism and infectious diseases.

With the help of their coach, teacher Angela Bell, the St Cuthbert's team researched criminal justice and interviewed lawyers and other experts. It turned them into passionate advocates for a more rehabilitative justice system.

Waymouth, 15, says the training has changed the way she thinks. "I apply the techniques to everyday things … If I hear about stuff on the news, I'll automatically think, 'What's causing this, what are the problems, how could this be solved?' It feels as if it's helping my brain develop a new way of questioning things."

For the competition, students are set the broad topics in advance, but are given a specific scenario – set 30 years in the future – on the day of the competition. They then have just over two hours to write a "booklet" with their proposed solution. "You have to be a fast writer, a fast thinker, and there's a lot of grit and determination involved," says Bell.

Imagination helps, too. "I like thinking creatively about the future – coming up with things that we don't have in today's world, but could possibly have in the future," says Mora, 16.

The solutions must be moral as well as creative, says St Cuthbert's principal Justine Mahon. "We want to develop young women who are ethical as well as smart. People don't just become ethical thinkers at 30 in the workforce. You need to practise that sort of thinking, and have those values instilled from a young age.

"Change is happening at an ever faster pace, and this generation can get hold of so much more information much more quickly, so it's even more important that they know how to sift it, analyse it and critique it."

Teams from 16 New Zealand schools attended this year's international competition. The most successful was a team of 11- and 12-year-olds from Hukerenui School, a small decile-5 school north of Whangarei. They won their age division in the "Community Problem-Solving" part of the competition. Rather than an imaginary future scenario, students had to identify and solve a problem in their community.

Principal Bastienne Kruger has taken three teams to the international competition, and they've won every time.

The 2015 team developed vacant land at the school into a farm with maize, lavender, alpacas and beehives.

The 2017 Hukerenui team built on that project. The problem they identified was that they had these great, real-life learning resources, but that there wasn't enough expertise within the school to make the most of them. Their solution was to develop the whole school's capability.

They talked to experts and planned lessons, teaching each class to become skilled. Years 3-4 became beekeepers, Years 5-6 experimented with compost and alpaca fibre and Years 7-8 grew lavender and distilled its oil. They built a website to sell the products, wrote a handbook, and negotiated to change the way subjects were taught.

"They ended up lifting the school's science achievement levels two years above their age level," says Kruger.

The school roll has doubled since these projects started, she says. "It doesn't take the place of maths, reading and writing, but we try to provide a time where students get to apply their knowledge to real-life learning and problem-solving."

Many of the students have started thinking big. "They're not going to work in McDonald's, they'll be leasing 5ha of land and planting maize, because they know how to do it. They know how to secure finance and they know how to draw up a lease. They know all of it."

More than 2000 young people took part in the international competition. The St Cuthbert's team came 24th out of 65 in their division. But more importantly, they say the process has given them more confidence in their ability to think and tackle hard subjects.

"There's a lot pessimism and hopelessness when people talk about the future," says Robinson, 15, "but future problem-solving helps me to look at the brighter side."